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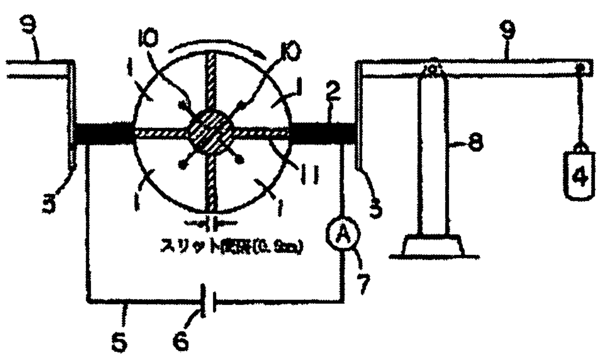
(54) [Title of the Invention] Copper Alloy of Excellent Resistance to Electric-Discharge Wear

(57) [Abstract]

[Problem] To obtain a copper alloy of excellent resistance to electric-discharge wear

[Means for Solving Problem] A copper alloy that contains 0.1 to 1.0 wt% Si, and, as required, that contains at least one or more of the following: 0.01 to 1.0 wt% Mg, 0.01 to 1.0 wt% Al, 0.01 to 1.0 wt% Ti, 0.01 to 1.5 wt% Cr, 0.01 to 1.0 wt% Mn, 0.01 to 3.0 wt% Fe, 0.01 to 3.0 wt% Co, 0.01 to 4.0 wt% Ni, 0.01 to 5.0 wt% Zn, 0.01 to 1.0 wt% Zr, 0.01 to 1.0 wt% Ag, and 0.01 to 2.0 wt% Sn, in a total amount of 0.01 to 6.0 wt%, and of which the balance is comprised of copper and unavoidable impurities.



[In figure]: slit gap (0.5 mm)

[Claims]

[Claim 1] A copper alloy of excellent resistance to electric-discharge wear characterized in that it contains 0.1 to 1.0 wt% Si and in that the balance is comprised of copper and unavoidable impurities.

[Claim 2] A copper alloy of excellent resistance to electric-discharge wear characterized in that it contains 0.1 to 1.0 wt% Si, and, as required, that contains at least one or more of the following: 0.01 to 1.0 wt% Mg, 0.01 to 1.0 wt% Al, 0.01 to 1.0 wt% Ti, 0.01 to 1.5 wt% Cr, 0.01 to 1.0 wt% Mn, 0.01 to 3.0 wt% Fe, 0.01 to 3.0 wt% Co, 0.01 to 4.0 wt% Ni, 0.01 to 5.0 wt% Zn, 0.01 to 1.0 wt% Zr, 0.01 to 1.0 wt% Ag, and 0.01 to 2.0 wt% Sn, in a total amount of 0.01 to 6.0 wt%, and of which the balance is comprised of copper and unavoidable impurities.

[Detailed Description of the Invention]

[0001]

[Technological field of the invention] This invention relates to a copper alloy that can be used in parts in which electric-discharge wear occurs such as in motor commutators or various types of contacts.

[0002]

[Prior art] Conventionally, oxygen-free copper, tough pitch copper, dephosphorized copper and copper containing silver of high electric conductivity have been used as materials for motor commutators or contacts. The reason for this is that materials of high electric conductivity generate little Joule heat on contact and have a high heat extraction effect, for which reason any increase in contact temperature can be inhibited and the amount of discharge is decreased. However, because of the requirement of increased reliability of commutators and various contact parts for automobiles, a long service life is sought. For this reason, the development of copper alloys of superior resistance to electric-discharge wear has become necessary as replacements for the pure copper materials described above.

[0003]

[Problems the invention is intended to solve] This invention was developed in light of the problems of the conventional technology as described above and its object is to provide a copper alloy of superior resistance to electric-discharge wear.

[0004]

[Means for solving the problems] The copper alloy of superior resistance to electric-discharge wear of this invention is characterized in that it contains 0.1 to 1.0 wt% Si and in that the balance is comprised of copper and unavoidable impurities. Further, as required, it contains at least one or more of the following: 0.01 to 1.0 wt% Mg, 0.01 to 1.0 wt% Al, 0.01 to 1.0 wt% Ti, 0.01 to 1.5 wt% Cr, 0.01 to 1.0 wt% Mn, 0.01 to 3.0 wt% Fe, 0.01 to 3.0 wt% Co, 0.01 to 4.0 wt% Ni, 0.01 to 5.0 wt% Zn, 0.01 to 1.0 wt% Zr, 0.01 to 1.0 wt% Ag, and 0.01 to 2.0 wt% Sn, in a total amount of 0.01 to 6.0 wt%, and of which the balance is comprised of copper and unavoidable impurities.

[0005] We shall now explain the reasons for the addition of the various components of the copper alloy of this invention and the reasons for the limitations on its composition.

Si: 0.1 to 1.0 wt%

Si is an essential component of the alloy of this invention. The oxide of Si (SiO_2) generates little free energy and it has a high melting point (1720°C), for which reason it is stable at high temperatures. In addition, it has high electric resistance at high temperatures ($3 \times 10^2 \Omega \cdot m$ at 1200°C). On the other hand, in the process in which a contact that has been heated by passage of an electric current is turned OFF, it is thought that discharge occurs due to interaction between electron emission and metal evaporation from the surface of the material. Moreover, because the oxide film is stable at high temperatures and has high electric resistance, it plays a role in rapidly extinguishing the discharge.

The inventors created this invention by discovering that this effect is important for parts in which discharge wear occurs such as in commutators and various contact parts, in addition to being important for electric conductivity. When the Si content is less than 0.1 wt%, this effect is decreased. When it exceeds 1.0 wt%, the effect is saturated and a decrease in electric conductivity and changes in hot rolling capacity are brought about. Consequently, the Si content is set at 0.1 to 1.0 wt%. A particularly preferred range is 0.2 to 0.8 wt%.

[0006] Mg, Al, Mn, Ag: 0.01 to 1.0 wt% each; Zn: 0.01 to 5.0 wt%; Sn: 0.01 to 2.0 wt%.

These elements are added with the objective of further intensifying a solid solution formation of the Cu-Si alloy. The most important property of contact materials is resistance to electric-discharge wear and it is necessary for the amount of mechanical wear to be low when the contact is repeatedly turned On and Off. Consequently, these elements are added appropriately to increase wear resistance. When the content of each is less than 0.01 wt%, there is little effect. Further, when the upper limit for each element is exceeded, the effect is saturated, and, except with Ag, there is a marked decrease in electric conductivity. Ag is expensive and the upper limit indicated above was defined by taking economic limitations into consideration. The preferred content of Mg, Al, Mn and Ag is 0.01 to 0.6 wt%, that of Zn is 0.03 to 3.5 wt% and that of Sn is 0.1 to 1.5 wt%.

[0007] Ti, Zr: 0.01 to 1.0 wt% for each

Cr: 0.01 to 1.5 wt%

Fe, Co: 0.01 to 3.0 wt% for each

Ni: 0.01 to 4.0 wt%

These elements form and intensify the deposition of Si and compounds as a result of their addition to the Cu-Si alloy. They are added appropriately like the elements described above with the objective of increasing wear resistance. When the content of each is less than 0.01 wt%, there is little effect. Further, when the upper limit of each element is exceeded, the effect is saturated and there is a marked decrease in electric conductivity. The preferred content of each is 0.05 to 1.0 wt% for Ti, 0.01 to 0.3 wt% for Zr, 0.05 to 1.0 wt% for Cr, 0.1 to 2.5 wt% each for Fe and Co and 0.3 to 4 wt% for Ni.

[0008] Two or more of the secondary components described above can be added together. When the total amount is less than 0.01 wt%, there is little effect in increasing strength. When it exceeds 6.0 wt%, there is a marked decrease in electric conductivity. Consequently, the total amount when these elements are added together, was set at 0.01 to 6.0 wt%. The preferable amount is 0.5 to 3%. Preferred combinations of secondary components are combinations of Ti (or Zr, Cr, Fe, Co, Ni) and Mg (or Al, Mn, Ag, Zn, Sn).

[0009]

[Working Examples] We shall now describe working examples of this invention by comparison with comparative examples. Copper alloys of the compositions shown in Table 1 were covered with charcoal, dissolved in an open atmosphere and cast using a Cryptol electric furnace and ingots of 50 mm in thickness, 75 mm in width and 180 mm in length were obtained. The surfaces

and back faces of these ingots were cut, after which they were hot-rolled at a temperature of 950°C to a thickness of 15 mm. Next, the oxide scale was removed with a grinder, after which the material was cold rolled and then annealed at a temperature of 500°C for 4 hours. Finally, it was made to a thickness of 4.0 mm by cold rolling. The Vickers hardness and the electric conductivity of the alloys of this invention and of the comparison alloys are both recorded in Table 1.

[0010]

[Table 1]

		Chemical components (wt%)			Conductivity (% IACS)	Vickers hardness (Hv)	Amount of wear (mg)
		Cu	Si	Secondary components			
Alloys of this invention	1	Balance	0.19	-	57	106	430
	2	"	0.52	-	32	117	360
	3	"	0.91	-	22	129	460
	4	"	0.48	Mg 0.34	26	155	370
	5	"	0.53	Al 0.41	20	161	450
	6	"	0.50	Mn 0.55	21	135	470
	7	"	0.51	Ag 0.10	31	124	310
	8	"	0.47	Zn 2.31	30	127	340
	9	"	0.52	Sn 1.28	21	172	420
	10	"	0.50	Ti 0.86	59	175	330
	11	"	0.53	Zr 0.21	38	145	340
	12	"	0.51	Cr 0.68	40	169	300
	13	"	0.52	Fe 1.49	42	158	320
	14	"	0.49	Co 1.73	51	177	300
	15	"	0.50	Ni 2.25	55	183	280
	16	"	0.54	Ni 2.23 Zn 1.14	53	185	270
	17	"	0.70	Ni 3.2 Mg 0.01 Zn 0.2 Mn 0.03	45	210	245
Comparison alloys	18	"	0.06	-	80	102	590
	19	"	1.13	-	18	133	560
	20	Tough pitch copper (C1100)			100	98	780
	21	Copper containing Ag (Cu-0.03 Ag)			99	105	630

[0011] Next, rotary electrified wear tests of the alloys of this invention and comparison alloys were performed. The tests were performed using the rotary electrified wear testing machine shown in Figure 1. As shown in the figure, alloys of this invention nos. 1 to 17 and comparison alloys nos. 18 to 21 were processed to disks of dimensions of 40 mmϕ × 4 mm [thickness]. A test disk 1, which was divided into four equal parts, was installed between insulators 11 to make a 4-pole rotator, one end of carbon brushes 2, 2 was brought into contact with the two polar surfaces of the rotator and the bottom parts of the plate springs were connected to the other end. One end of pressurized jigs 9, 9 was connected to the top ends of plate springs 3, 3 and a weight 4 was connected to the other end. Reference 10 is a lead wire for passage of electricity that is connected to the test disk 1, reference 5 is a wire that is connected to the carbon brushes 2, 2, reference 6 is a direct-current power source, reference 7 is an ammeter and reference 8 is the support column of the pressurized jig.

[0012] In the apparatus described above, the contact pressure between the test disk 1 and the carbon brush 2 was adjusted to 435 g/cm^2 using the weight 4. In this state, electricity was passed into the test disk 1 at a current density of 0.2 A/mm^2, the motor was rotated at a peripheral speed of 6.3 m/sec (rotational speed: 3000 rpm) and an electrified rotation wear test was performed. The amount of wear of the test disk 1 was studied after 400 hours in an air atmosphere at 15°C. The results are shown in Table 1.

[0013] The alloys of this invention which contained 0.1 to 1.0 wt% Si, had excellent electric conductivity and hardness and were of superior resistance to

electric-discharge wear. On the other hand, comparison alloy no. 18 contained little Si, and had little effect on improving the resistance to electric-discharge wear. Further, because no. 19 contained an excessive amount of Si, the electric conductivity was decreased and there was a large amount of wear. Nos. 20 and 21 did not contain Si. Although they had superior electric conductivity, there was a large amount of wear.

[0014]

[Effect of the invention] As described above, the copper alloys of this invention exhibit the superior resistance to electric-discharge wear of materials of low electric conductivity by comparison to conventional products, and, for example, contribute to an increase in the service life of motor commutators and various types of connection parts.

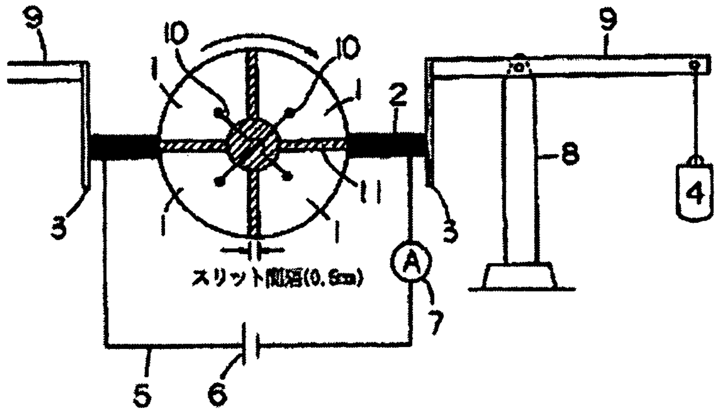
[Brief Explanation of the Figure]

[Figure 1] This is a lateral view of the rotary electrified wear testing machine that tests resistance to electric-discharge wear.

[Explanation of symbols]

1 test disk

2 carbon brush



[In fig.] slit gap (0.5 mm)